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EP 0624900 A2 EP 0414372 A2 WO 91/03074 A1
WPI Abstract Accession No. 91-058893/09 &
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(58) Field of Search
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(54) Processing silicon in a plasma etch system

(57) A method is provided for processing silicon substrates (1), in which the silicon substrate is introduced into a plasma etching system. A trench (3) having a side-wall passivation (4) is generated by a first etching step using an etching gas eg. SF_6 and a passivating gas eg. CHF_3. The underetching (6) is then generated by a further isotropic plasma etching step using the etching gas only. The structures (7) formed may be used eg. as acceleration sensors.

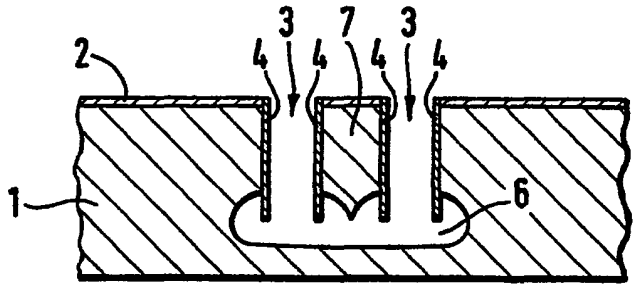

FIG. 3

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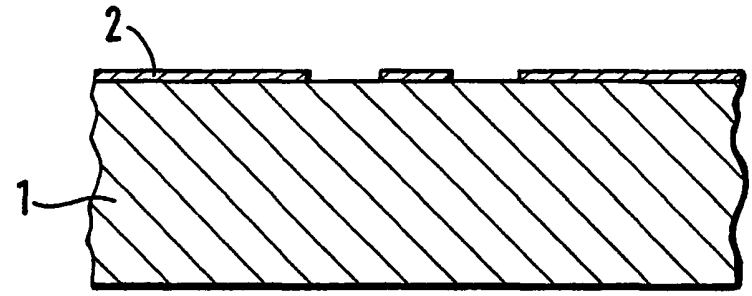

FIG. 1

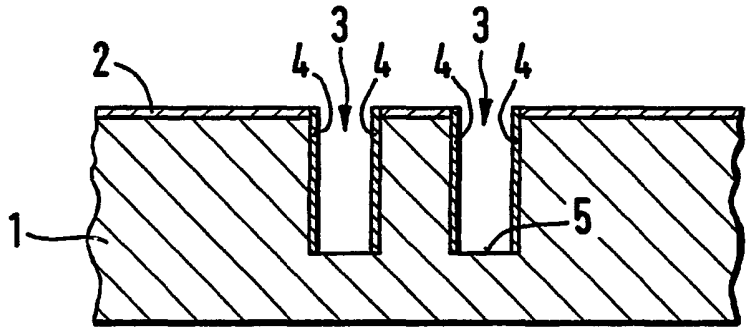

FIG. 2

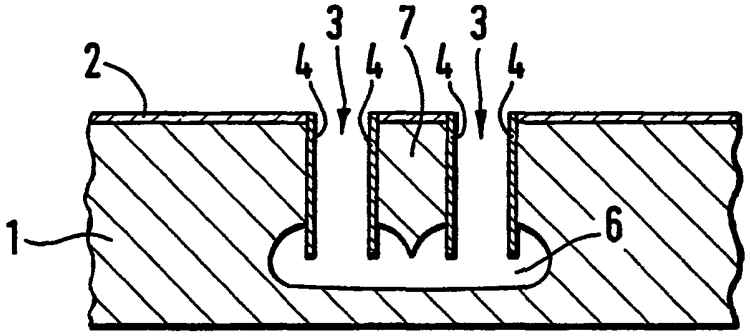

FIG. 3

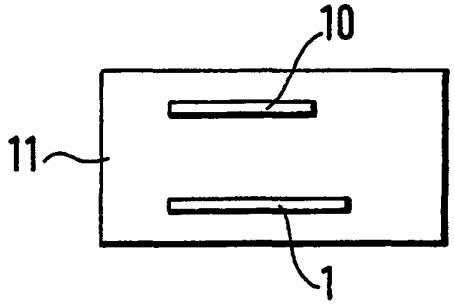

FIG. 4

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Method of processing silicon

Prior art

The invention proceeds from a method of processing silicon in accordance with the generic class of independent Claim 1. US-4 784 720 has already disclosed a method of processing silicon in a plasma etching system, in which method an etching gas and a passivating gas are used. Employing the etching gas and the passivating gas creates a trench having a side-wall passivation. The etching gas used is a chlorine or bromine supplier. Since chlorine and bromine bring about an appreciable etching of silicon only at relatively high ion energies in the plasma, only strongly anisotropic etching profiles can be achieved with these etching gases. DE 39 27 163 A1 discloses a method of processing silicon in which an etched trench is generated which has a side-wall passivation. Proceeding from the floor regions of the trenches, structures can then be underetched by isotropic plasma etching. Since a low-temperature oxide or low-temperature nitride is provided as side-wall passivation, the method requires a plurality of processing steps in different etching systems and deposition systems (plasma etcher, PECVD system or LPCVD system).

Advantages of the invention

On the other hand, the method according to the invention having the characterizing features of independent Claim 1 has the advantage that not only can a trench having a sid -wall passivation be generated but the structures so formed can also be is tropically underetched in on and the same etching system without

the wafer having to be removed from the system in the meantime. A particularly simple method with which underetched silicon structures can be generated is thus specified.

The measures cited in the dependent claims make possible advantageous further developments and improvements of the method specified in the independent claim. The reinforcement of the side-wall passivation improves the lateral etching resistance of the silicon structures in the subsequent isotropic underetching. Silicon can be processed particularly easily and at high etching rates by means of a fluorine plasma. Process gases containing a fluorocarbon or fluorinated hydrocarbon form a side-wall passivation composed of a chemically particularly resistant fluoropolymer. As a result of low ion energy, simple and thin etch maskings can be used and large differences in the etching rate of silicon substrate and masking substance can nevertheless be achieved. This applies, in particular, at high plasma densities and low ion energy. Deep and narrow trench structures having a side-wall passivation can be formed by the alternating or simultaneous use of etching gas and passivating gas.

Drawings

Exemplary embodiments of the invention are shown in the figures and explained in greater detail in the description below. Figure 1 shows a silicon substrate with an etch masking, Figure 2 shows etched trenches with side wall passivation introduced into the latter, Figure 3 shows the underetching proceeding from the floor region of the trenches and Figure 4 shows a plasma etching system.

Description of the invention

Figure 1 shows a silicon substrat 1 with an

applied etch masking 2. The etch masking 2 does not cover the surface of the silicon substrate in specified regions. In these regions, an etch attack on the silicon is carried out in the subsequent process steps. Suitable as materials for the etch masking 2 are, for example, a thin layer of photoresist or silicon oxide. The silicon substrate 1 is introduced into a plasma etching system for subsequent processing.

Figure 2 shows the silicon substrate 1 after a first plasma etching step. Trenches 3 are introduced by etching in the regions which were not covered by the etching mask 2. At the same time, the trenches 3 have a side-wall passivation 4. In the region of the floor 5, the trenches 3 are not covered by a passivating layer 4, with the result that the silicon of the substrate 1 is exposed at that point. The trenches 3 are etched in by employing a gas which etches silicon isotropically and a gas which forms a passivating layer. The isotropically etching gas used is a gas which supplies fluorine, for example SF_6 or NF_3. The passivating gas used is a Teflon(RTM)-forming monomer, as a rule a fluorocarbon or fluorinated hydrocarbon (CHF_3, C_2F_6, C_2F_4, C_4F_8). The etching gas and passivating gas can be used simultaneously in the plasma etching system in a suitable mixture. Alternatively, it is possible to carry out alternately a multiplicity of consecutive etching and passivating steps. In this way, perfectly anisotropically etched trenches 3 of great depth (several 10 μm) and small width (a few μm) can be achieved in the plasma even at low ion energies (a few electron volts) assuming a high plasma density. Because of the low ion energy, the erosion of the etching mask 2 is small. As a consequence of the ion action, the floor 5 of the trenches 3 remains free and is not covered by the Teflon(RTM)-type fluoropolymer film of the side-wall passivation 4. Furthermore, it is also possible to add additional gases such as nitrogen, oxygen or argon in order to modify the processing properties of the etching process. In order to ensure an adequate plasma density,

i.e. an adequately high concentration of chemically reactive ions, despit th low ion energy, the plasma etching system should have a suitable source and, for example, a microwave or magnetron plasma excitation system.

After the desired etched depth of the trenches 3 has been reached, the actual etching gas supplying fluorine can be shut off and only the Teflon(RTM)-forming passivating gas supplied. As a result of this process, the thickness of the side-wall passivation 4 can be increased. During this process, simultaneous ion action ensures that the passivating film forms selectively only on the side walls of the trenches 3 and not on the etched floor 5.

Figure 3 shows the trenches 3 after a further etching step. In said further etching step, the silicon substrate 1 is processed exclusively with the fluorine-supplying etching gas. In this process, the chosen energy of the plasma is in the order of magnitude of only a few electron volts, with the result that the etching takes place almost perfectly isotropically. The underetching 6 then forms proceeding from the exposed etched floor 5 of the trenches 3, as is shown in Figure 3. In this process, the ion energy is not set exactly equal to zero electron volts in order to still be able to remove accidental microscopic deposits on the floor 5 during the isotropic underetching. Because of the low ion energy, ions accidentally striking the side wall are scarcely responsible for any attack on the side-wall passivation 4 or on the etching mask 2. If, as is shown in Figure 3, two trenches 3 are disposed immediately next to one another, a silicon web 7 which is disposed between the two trenches 3 can be completely detached from the substrate 1 by the isotropic underetching 6. Such structures make it possible to achieve, for example, thin deflection tongues or comb structures which can be used as acceleration sensors.

A particular advantag of th process sequence

shown in Figures 1 to 3 is that all th etching processes can be carried out in one process without interruption or outward transfer of the wafer in one and th same plasma system. The etching gases and passivating gases mentioned can be utilized with one another or after one another in one and the same etching system. Furthermore, they enable the formation of particularly narrow and deep trenches 3 which can be underetched in a subsequent process step. In this way, structures can be generated which can be employed as sensors.

Figure 4 shows diagrammatically a plasma etching system 11. The silicon substrate 1 and a further plasma-generating means 10 are introduced into the plasma etching system 11. A high-frequency voltage which determines the energy with which ions strike the substrate 1 can be applied to the substrate 1. The further plasma-generating means 10 can be designed as a simple electrode, a microwave generator, a magnetron or any other plasma source which generates a high plasma density.

Claims

1. Method of processing silicon, in which a silicon substrate (1) is provided with an etch masking (2) and introduced into a plasma etching system and exposed to a plasma, a trench (3) having a side-wall passivation (4) being generated by processing with an etching gas and a passivating gas, characterized in that an underetching (6) proceeding from the etched floor (5) of the trench (3) is introduced in the etching system by the etching gas in a further processing step.

2. Method according to Claim 1, characterized in that the side-wall passivation (4) is reinforced by a deposition step prior to introducing the underetching (6) by etching.

3. Method according to one of the preceding claims, characterized in that a fluorine-supplying gas (for example, SF_6 or NF_3) is selected for the etching gas.

4. Method according to one of the preceding claims, characterized in that a gas supplying fluorocarbon or fluorinated hydrocarbon (for example, CHF_3, C_2F_6, C_2F_4, C_4F_8) is selected as passivating gas.

5. Method according to one of the preceding claims, characterized in that the plasma energy is less than 50 electron volts, preferably less than 10 electron volts.

6. Method according to one of the preceding claims, characterized in that, to introduce the trench (3), the silicon substrate (1) is alternately processed with the etching gas and the passivating gas.

7. Method according to one of Claims 1 to 5, charact rized in that, to introduce th trench (3), the silicon substrate (1) is simultan ously processed with a mixture of the etching gas and the passivating gas.

8. A method of processing silicon substantially as h rein described with ref rence to th accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report) 8	Application number GB 9511873.3
Relevant Technical Fields (i) UK Cl (Ed.N) H1K-KGCCT, KLECX (ii) Int Cl (Ed.6) H01L-21/306	Search Examiner S J DAVIES Date of completion of Search 24 AUGUST 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE WPI, INSPEC	Documents considered relevant following a search in respect of Claims :- ALL

Categories of documents

X:	Document indicating lack of novelty or of inventive step.	**P:**	Document published on or after the declared priority date but before the filing date of the present application.
Y:	Document indicating lack of inventive step if combined with one or more other documents of the same category.	**E:**	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A:	Document indicating technological background and/or state of the art.	**&:**	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X,Y,P	EP 0624900 A2 (DELCO) see acknowledged prior art of Figures 1a-1f	X: 1, 5, 6 Y: 3, 4, 7
Y	EP 0414372 A2 (SONY) see eg column 2, lines 3-29	4, 7
X, Y	WO 91/03074 A1 (ROBERT BOSCH) see eg Figures 1a-1g	X: 1, 5, 6 Y: 3, 4, 7
X, Y	WPI Abstract Accession No 91-058893/09 & DE 3927163 (BOSCH) 21 February 1991 (see abstract)	X: 1 5 6 Y: 3 ~ 7

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